ACTIVE SWAY CONTROL OF A GANTRY CRANE SYSTEM USING DELAYED FEEDBACK SIGNAL CONTROLLER

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ABSTRACT

Gantry Cranes are common industrial structures that are used in building construction, factories, and harbors. These cranes are usually operated manually. With the size of these cranes becoming larger and the motion expected to be faster, the process of controlling them became difficult without using automatic control methods. In general, the movement of cranes has no prescribed path. Cranes have to be run under different operating conditions, which makes closed-loop control preferable. The aim of this project is to develop a controller to reduce the sway angle of the rope for a two-dimensional gantry crane system. The 2D-gantry crane system consists of a cart, rope, payload, actuator as well as controller. In this project, the control technique to be implemented to control the sway angle of the rope is Delayed Feedback Signal (DFS). In DFS, the control signal is calculated based on delayed position feedback. The performance on system in 2D-gantry crane focused on the sway angle of the hoisting rope and its corresponding Power Spectral Density (PSD) on the sway angle response. Finally, the comparative assessment of the effects of the system using DFS controller is tested by using different values of the parameters such as mass of the load, length of the rode and the initial point of release load.

ABSTRAK

Kren Gantri adalah struktur industri umum yang digunakan dalam pembinaan bangunan, kilang, dan pelabuhan. Kren ini biasanya dikendalikan secara manual. Dengan saiz kren yang lebih besar dan gerakan yang diharapkan akan lebih cepat, proses kawalan kren tersebut menjadi sukar tanpa menggunakan kaedah kawalan automatik.Objektif projek ini ialah untuk membina pengawal untuk mengurangkan ayunan pada kren gantri dua dimensi. Sistem kren gantri 2-D dilengkapi dengan pengangkut,tali dan beban sebagai pengawal. Dalam projek in,teknik untuk mengawal yang digunakan dalam melaksanankannya ialah Tangguhan Masa Maklumbalas. Tangguhan Masa Maklumbalas dikira berdasarkan pada tangguhan posisi maklumbalas. Pada persembahan untuk sistem kren gantri 2-D difokuskan pada ayunan pengankutan tali dan Kepadatan Kuasa Spektral. Akhirnya, penilaian perbandingan kesan penggunaan DFS controller ke atas sistem diuji dengan menggunakan nilai yang berbeza dari segi parameter jisim beban, panjang rod dan sudut awal beban dilepaskan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

DFS	Delay Feedback Signal
PSD	Power Spectral Density

CHAPTER 1

INTRODUCTION

1.1 Crane : Overview

In our environment, it is hard to lift or transfer a heavy object from one place to another place. To solve that problem, cranes are commonly employed in industries either in domestic industries or warehouse. For example, crane is used in transport industry for the loading and unloading of equipment, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy material. These materials are usually heavy, large and hazardous, which cannot be handling by workers. A crane consists of a hoisting and a support mechanism. The loads suspended on cables from a hook at a point on the support mechanism. Then, the support mechanism will move the hanged load into the crane workspace. After that, the hoisting mechanism will lift the load to be placed to the desired. One of the challenging in the control of the cranes is to reduce the swaying. These sway typically caused by movement of the trolley. This swaying not only reduces the efficiency of the cranes, but also can cause safety problem in the complicated working environment.

1.1.1 Type of Crane

Crane can be dividing into two types, mobile crane and fixed crane which they have a different function.

1.1.1.1 Mobile Crane

A mobile crane is generally a crane which consist a travelling device with rubber-tired wheel that is easily moveable from one location to another. The mobile crane provides great mobility during operations in the site area. Mobile crane is responsible for the most accidents and injuries. To avoid a serious injury due to an accident, it must be operated by trained staff. Besides that, the staff also should to wear safety boot, hard hats and high visibility clothing when working around the crane. To ensure that the load is properly installed, a spotter must be required. The advantage of a mobile crane is it can be easily moved from one site to the other site. It also makes operations easy and fast by moving quickly to any point within a jobsite. Otherwise, the mobile crane does not need any special installation. It can start working as soon as it enters the site. Mobile crane is widely used today in the fields of transportation, construction, mechanical manufacturing factories etc. In transportation industry a mobile crane is commonly used on harbors and airports, to load and unload heavy objects. While in the construction industry, mobile crane plays an important role in shifting heavy construction material and blocks. In some factories, mobile crane is used to assemble heavy metal spare parts. There are several types of mobile crane commonly use like truck, side lift, aerial crane, railroad, and crawler.

Most people are familiar with the truck crane. A truck mounted crane is great for move heavy construction loads. All work truck cranes provide 360° rotation when mounting on truck bed. Hand pump actuates hydraulic cylinder to lift loads.

This crane is able to travel on main roads and highways. However, the movement or speed of a truck mounted crane is quite slow, because of its heavy load. This additional flexibility makes it possible to transport large loads and access a wide range of locations.

Figure 1.1: Truck Crane

Another type of mobile crane is side lift. This crane is able to transport materials and hoist large containers. The added benefit of this mobile crane is that it can be used to lift a container either from the ground or from a railway vehicle. To lift a very large containers are using a pair of side lift cranes. Aerial crane is another type of mobile crane which able to travel or to lift in areas that are difficult to reach by other cranes. Ariel cranes are most commonly used in construction of building or tower. They can lift anything within their lifting capacity. It is also cable to use in extinguishing the fire with carry a bucket of water and pour onto the fire.

Figure 1.2: Side Lift Crane

Figure 1.3: Aerial Crane

A railroad crane is specifically designed with flanged wheels so it can travel along railroad tracks. These units are used for maintenance work and loading freight into railway cars. On occasion, they are also involved in recovery operations when trucks tip over or spill their load. The other mobile crane is crawler crane which it able to work on soft ground. It is made more stable allows users to avoid the process to stabilize the crane. One of the features that allow a crawler crane to lift such enormous loads is a counterweight. Some of the larger crawler crane counterweight assemblies weigh as much as several hundred tons. Many crawler cranes have booms that reach several hundred feet in the air. Such reach and lift capabilities make the machines perfect for large construction projects.

Figure 1.4: Rail Road Crane

Figure 1.5: Crawler Train

1.1.1.2 Fixed Crane

Fixed crane is described as a crane of which the principal structure is mounted on permanent or semi permanent foundations. They do not move during used this crane. Usually fixed crane have the ability to lift and move the greater loads due to their increase stability. A fixed crane has a greater weight capacity and can lift loads much higher compare to mobile crane because it does not have the mobility of other types of cranes. With this great power of the fixed crane also comes a great potential danger that will cause a very serious injury or death. When using such a crane on a construction site, or any other type of site, and a load drops from it, it is almost impossible to stop the load from hitting the ground or anyone in its path. The worker must be wear protective clothing and safety gear, such as safety glasses, a hard hat, and steel-toed shoes to avoid the serious injury due to an accident. They are several different types of fixed crane like gantry crane, overhead crane, tower crane, rotary crane, jib crane and telescopic crane.

Gantry crane are very common in factories, where they are designed to move the material or equipment along the factory floor as the product is slowly assembled. The gantry crane may also be used to move the parts around, typically along the assembly line as the components are assembled. Each gantry crane is able to lift only one material with a maximum amount and cannot be exceeded. It is not easy to move a heavy weight on the end. The operator must be aware to handle this crane to avoid an accident.

Figure 1.6: Gantry Crane

Other type of fixed cranes commonly used in construction is overhead crane which is permanently fixed in place overhead for moving huge volumes of material and heavy material which cannot be moved easily by hand. These cranes are also used at ports all over the world, to carry container or material from the ships or to transfer into the ship. These cranes tend to be quite large, very expensive, and ca with a movable bridge that carries a hoisting mechanism and travels on a fixed runway structure.

Rotary crane also included in the group of fixed crane. They are two types of rotary crane; boom crane and tower crane are common industrial structures that are used in building construction, factories, and harbors. These designed to move or transport very large material. With the size of these cranes becoming larger and the motion expected to be faster, the process of controlling them became difficult

without using automatic control methods. In general, the movement of cranes has no prescribed path. A tower crane is used in the construction of tall buildings. Tower cranes are fixed to the ground during the construction period.

Figure 1.7: Overhead Crane

Figure 1.8: Tower Crane

A jib crane is a type of crane where a horizontal member, supporting a moveable hoist, is fixed to a wall or to a floor-mounted pillar. Jib cranes are usually used in industrial premises and on military vehicles. The jib may swing through an arc, to give additional lateral movement, or be fixed. Similar cranes, often known simply as hoists, were fitted on the top floor of warehouse buildings to enable goods to be lifted to all floors.

A telescopic crane is one of the fixed cranes. It has a boom that consists of a number of tubes fitted one inside the other. A hydraulic or other powered mechanism extends or retracts the tubes to increase or decrease the total length of the boom. These types of booms are often used for short term construction projects, rescue jobs, lifting boats in and out of the water. The relative compactness of telescopic booms makes them adaptable for many mobile applications, often of short duration.

Figure 1.9: Jib Crane

Figure 1.10: Telescopic Crane

1.1.2 Gantry Crane

Gantry crane is used in most demanding environments where very heavy equipment and machines have to be lifted. It is usually used to loads in areas which have restricted access. We can easily locate a gantry crane at factories to lift loads and equipment which ordinary cranes might not be able to lift.

This types of cranes in-corporate a trolley, which meaning in a horizontal plane. The payload is attached to the trolley by a cable, whose length can be varied by a hoisting mechanism. The load with the cable is treated as a one-dimensional pendulum with one-degree-of-freedom sway. There is another version of these cranes, which can move also horizontally but in two perpendicular directions. The analysis is almost the same for all of them because the two-direction motions could be divided into two uncoupled one-direction motions.

Gantry Crane is used to lift heavy objects with the help of a hoist which is fixed in trolley. The hoist can move horizontally on a rail which is fixed under the beam. Gantry cranes have wheels on the foot of the crane which allows it to traverse. The wheels of the crane rest on a supporting beam which is fixed parallel to the factory wall or any other large building. Some gantry cranes are fixed and are used to move railway cargo.

Figure 1.11: Gantry Crane at factory